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2

[57] 申請專利範圍:

1. 一種由至少第一和第二不同的聚合物材料以實質上平行的交替層排列而形成的多層反射聚合物本體, 該本體具第一和第二主面, 其特徵為: 該第一與第二聚合物材料之折射指數彼此至少差0.03, 本體包含足夠多層, 因此本體可反射撞擊其第一面上之光之至少40%, 而可透射由第二主面導引通過本體之光之至少5%者。
2. 如申請專利範圍第1項之反射聚合物本體, 其又包含一種著色劑摻混於或存在於第一和第二主面中之至少一面之其內或其上, 因此當本體照光時, 本體呈現著色劑之顏色者。
3. 如申請專利範圍第2項之反射聚合物本體, 其中著色劑係由顏料與染料中選出者。
4. 如申請專利範圍第1項之反射聚合物本體, 其中第一聚合物材料為聚胺甲酸酯而第二聚合物材料為聚甲代丙烯酸甲酯者。

5. 如申請專利範圍第1項之反射聚合物本體, 其中第一聚合物材料為聚胺甲酸酯而第二聚合物材料為聚醚醯亞胺者。
6. 如申請專利範圍第1項之反射聚合物本體, 其中第一聚合物材料為聚碳酸酯而第二聚合物材料為聚亞乙烯氯與聚甲代丙烯酸甲酯之可相溶混的摻合物者。
7. 如申請專利範圍第1項之反射聚合物本體, 其中: 該第一聚合物材料為聚苯乙烯而第二聚合物材料為乙烯與至少一種不飽和一羧酸之共聚物者。
8. 如申請專利範圍第1項之反射聚合物本體, 其中第一聚合物材料為聚碳酸酯而第二聚合物材料為聚甲代丙烯酸甲酯者。
9. 如申請專利範圍第1項之反射聚合物本體, 其中第一和第二主面中之至少一面具有經擦刷、粗礫化或粗化的表面者。





8-10/9102 specification, claims, abstract and  
drawings of the cited Taiwanese  
patent appln. as originally filed  
with the Taiwanese Patent Office.

-1-

## POLYMERIC REFLECTIVE MATERIALS UTILIZING A BACK LIGHT SOURCE

The present invention generally relates to a  
5 multilayer reflective polymeric body or film which, when  
illuminated by means of a back light source, transmits  
such light. The invention also relates to articles  
produced therefrom which include decorative trim,  
10 lighting lenses for automotive, commercial and  
residential lighting applications, and structural parts  
such as refrigerator doors. The present invention also  
relates to a method by which such articles can be  
produced from the multilayer reflective polymeric body  
15 or film without causing undesirable iridescent colors.

By way of example, in the automotive industry,  
automobile stylists and designers are always seeking  
ways in which a particular vehicle's appearance can be  
20 differentiated. Most recently, automobiles have been  
approaching very similar designs in view of the rather  
limited number of ways in which automobile bodies can  
be aerodynamic as well as fuel efficient. Consequently,  
stylists and designers are faced with the formidable  
25 task of differentiating such vehicles.

To the extent that vehicle headlights and  
taillights are required for functional purposes, designs  
of the vehicle adjacent to areas where lights are needed  
30 have been limited since the associated lighting lenses  
disrupt the styling contours on the vehicle and exhibit  
color mismatches. Thus, it is desirable to be able to  
render vehicle lights indiscernible by blending the  
35 vehicle body lines, colors, and/or decorative trim with  
a reflective and/or colored surface which conceals the

lighting, and yet conforms to standard lighting requirements when the lights are illuminated.

Such a design option would also find utility in a wide variety of other areas in addition to the 5 automotive industry. For example, in the area of consumer appliances, the housings on such appliances could be made to exhibit one color or appearance when viewed and yet permit internal items to become visible when illuminated. For example, a refrigerator door or 10 portion thereof could be reflective and/or colored to match, blend, or contrast with the remainder of the appliance and yet become transparent when illuminated by a light inside the refrigerator so as to expose its 15 contents to view without opening the door.

Additionally, in the areas of commercial and residential lighting, it would be desirable to be able 20 to provide lights which would blend in with the chosen decor, and yet illuminate a room when turned on. This would expand on the variety of options available for interior decoration and the styles of lamps and lighting. For example, in restaurants, and nightclubs, 25 hand rails, floor tiles, panels, etc., it would be desirable to have such items reflective in appearance yet appear differently when back lit.

Conventional methods for fabricating reflective surfaces include forming such surfaces of highly 30 polished metals. Such polished metal surfaces are useful to reflect light but such surfaces are opaque and they cannot be used to hide lamps or other lighting from view. Because of the high costs, weight, environmental 35 concerns, and fabricating problems involved in using

metals, there has been a shift to use plastic surfaces which contain thin coatings of metal thereon.

Thus, metal coated plastic articles are now commonly found as both decorative and functional items 5 in a number of industries. Such articles are used as bright work for consumer appliances such as refrigerators, dishwashers, washers, dryers, and radios. These types of articles are also used by the automotive 10 industry as head lamp reflectors, bezels, radio knobs and automotive trim. Again, however, such reflective surfaces are designed to be substantially opaque and cannot be used to conceal lamps or other lighting from view.

15 There have been a wide multitude of lighting designs in several areas such as the automobile industry. For example, Goldbaum et al., U.S. Patent No. 3,321,618 disclose an automotive vehicle lamp assembly 20 with a snap-in lens and Kirsch, U.S. Patent No. 4,020,338 discloses an automobile lighting lens which provides an adaptor for styling headlights. Further, Egawa et al., U.S. Patent No. 5,005,949, discloses an anti-glare covering for illuminated lights which 25 substantially reduces perceived glare from lighting. However, none of these attempts in the art provide a lighting lens or covering which possesses the desired feature of reflectivity and yet transmissivity upon exposure to a back light source.

30 Multilayer articles of polymers are known, as are methods and apparatus for making such articles. For example, such multilayered articles may be prepared 35 utilizing multilayer coextrusion devices as described in commonly-assigned U.S. Patent Nos. 3,773,882 and

3,884,606 to Schrenk. Such devices are capable of simultaneously extruding diverse thermoplastic polymeric materials in substantially uniform layer thicknesses. U.S. Patent 3,733,882 teaches a method for the preparation of a composite stream of interdigitated diverse synthetic resinous materials. The steps of the method are providing at least a first stream and a second stream of heat plastified extrudable thermoplastic material; dividing each of the streams into a plurality of first substreams and a plurality of second substreams, respectively; combining the substreams to form a composite stream having the first substreams and the second substreams interdigitated, with the further limitation that the substreams are combined at locations which are generally disposed on an arc of a circle; deforming the composite stream by causing the substreams thereof to flow in a generally radially inward manner to a discharge location generally disposed at the center of the circle; the discharge location being generally equidistant from locations of combination of adjacent first and second substreams; removing the composite stream from the discharge location; and deforming the stream into a generally sheet-like configuration wherein the interfaces between streams are generally parallel to the major surfaces of the sheet-like configuration. U.S. Patent 3,884,606 teaches an apparatus for the preparation of a multilayer film or sheet, the apparatus comprising a body, the body defining at least a first polymer entrance passage, a first plenum in communication with the first polymer passage, a stream dividing means to divide material flowing from the first passage into a plurality of first substreams, second polymer receiving means in operative communication with a second plenum, the second plenum

discharging to the dividing means which divides the  
second stream into a plurality of second substreams and  
interdigitates the plurality of second substreams with  
the first substreams, the dividing means being in  
operative communication with a third or composite stream  
5 receiving plenum, the composite stream comprising the  
combined first and second substreams, a third plenum  
discharge passage in operative communication with the  
third plenum and adapted to receive the composite  
10 stream from the third plenum, the discharge means being  
in combination with a die having a generally slot-like  
extrusion orifice, the discharge passage having a first  
or receiving end and a second or discharge end, the  
improvement which comprises disposing the discharge  
15 portion of the stream dividing means in an arcuate  
manner to form an arc of a circle wherein the discharge  
portion is generally equidistant from the discharge end  
of the third plenum discharge passage. The number of  
layers may be multiplied by the use of a device as  
20 described in commonly-assigned U.S. Patent No. 3,759,647  
to Schrenk et al which describes an apparatus for the  
preparation of a composite synthetic resinous sheet-like  
article having in cooperative combination a means for  
providing at least two streams of heat plastified  
25 thermoplastic resinous material, a means for  
mechanically arranging the two streams into a composite  
stream having a plurality of generally parallel layers  
wherein a portion of one stream encapsulates the  
composite stream, a means for mechanically manipulating  
30 the composite stream to provide an increased number of  
layers in the manipulated stream, and a means for  
shaping the manipulated stream into a desired  
configuration having a plurality of layers generally

parallel to a major surface of the desired configuration.

Alfrey, Jr. et al., U.S. Patent No. 3,711,176, teach a multilayered highly reflective thermoplastic body fabricated using thin film techniques. That is, the reflective thin film layers of Alfrey, Jr. et al. relied on the constructive interference of light to produce reflected visible, ultraviolet, or infrared portions of the electromagnetic spectrum. Such reflective thin films have found use in decorative items because of the iridescent reflective qualities of the film. Also, Cooper, U.S. Patent No. 4,310,584 (Re. 31,780) teaches improvements in multilayer light-reflecting film are effected by the use of a transparent thermoplastic resinous laminate film of at least 10 very thin layers of substantially uniform thickness, said layers being generally parallel, the contiguous adjacent layers being of different transparent thermoplastic resinous materials one of which is a thermoplastic polyester or copolyester resin having a refractive index of 1.55-1.61 and the adjacent resinous material having a refractive index which is lower by at least about 0.03, the contiguous adjacent layers differing in refractive index by at least about 0.03.

However, the films of Alfrey, Jr. et al. are extremely sensitive to thickness changes, and it is characteristic of such films to exhibit streaks and spots of nonuniform color. Further, color reflected by such films is dependent on the angle of incidence of light impinging on the film. Thus, such films are not practical for uses which require uniformity of reflectivity. Moreover, such films are not practical to thermoform into articles since localized thinning of the

layers during thermoforming causes alterations in the reflective characteristics of the films.

More recently, reflective multilayer polymeric films and sheets formed of optically thick layers (optical thickness of greater than about 0.45  $\mu\text{m}$ ), a combination of optically thick and optically very thin layers (optical thickness of less than about 0.09  $\mu\text{m}$ ), or combinations of optically thick, optically thin, and optically very thin layers have been taught which exhibit a substantially colorless uniform silvery reflective appearance. Wheatley et al., U.S. Patent No. 5,122,905 describes a multilayered reflective body which is thermoformable and capable of being fabricated into relatively thick parts while maintaining a uniform reflective appearance is provided. The reflective polymeric body includes at least first and second diverse polymeric materials of a sufficient number of alternating layers of the first and second polymeric materials such that at least 30% of the light incident on the body is reflected. A substantial majority of the individual layers of the body have an optical thickness of at least 0.45 micrometers, and adjacent layers of the first and second polymeric materials differ from each other in refractive index by at least about 0.03. The reflective body may be fabricated into sheets, mirrors, noncorroding metallic appearing articles and parts, reflectors, reflective lenses, and the like. Another to Wheatley describes a multilayered reflective body which is thermoformable and capable of being fabricated into films, sheets, and a variety of parts while maintaining a uniform reflective appearance is provided. The reflective polymeric body includes at least first and second diverse polymeric materials of a sufficient

number of alternating layers of the first and second polymeric materials such that at least 30% of the light incident on the body is reflected. A substantial majority of the individual layers of the body have an optical thickness of not more than 0.09 micrometers or not less than 0.45 micrometers, with at least one of the individual layers having an optical thickness of not more than 0.09 micrometers, and adjacent layers of the first and second polymeric materials differ from each other in refractive index by at least about 0.03. Yet another U.S. Patent No. 5,126,880 to Wheatley et al. which a multilayered, highly reflective polymeric body comprising at least two types of optical layers which is thermoformable and capable of being fabricated into films, sheets and a variety of parts while maintaining a uniform reflective appearance is provided. The reflective polymeric body includes at least first and second diverse polymeric materials having a sufficient number of layers of the first and second polymeric materials such that at least 30% of light incident on the body is reflected. A portion of the layers have optical thicknesses between 0.09 and 0.45  $\mu$  m, and the remaining layers have optical thicknesses of not greater than 0.09  $\mu$  m or not less than 0.45  $\mu$  m. The first and second polymeric materials differ from each other in refractive index by at least about 0.03. These U.S. patents teach using these reflective films and sheets for many of the same uses as polished metal and metallized plastic sheets have been heretofore used.

Accordingly, the need still exists in this art for a polymeric body or film which is reflective, and yet is capable of transmitting light upon exposure to a back light source for a variety of applications

including automotive, commercial, and residential applications. There is also a need for a method of forming such a polymeric body or film into a variety of useful shapes.

5        The present invention meets the above-described needs by providing a polymeric body which is reflective in appearance, and yet which transmits light upon exposure to a back light source and by providing a method for forming such a polymeric body into useful 10 shapes. The terms "reflective", "reflectivity", "reflection", and "reflectance" as used herein refer to total reflectance (that is, ratio of reflected wave energy to incident wave energy) sufficiently specular in 15 nature such that the polymeric body has a metallic appearance. The use of these terms is intended to encompass semi-specular or diffuse reflection such as that of brushed metal or pewter. In general, reflectance measurement refers to reflectance of light 20 rays into an emergent cone with a vertex angle of 15° centered around the specular angle.

25        A specific intensity of reflectance, when used herein, is the intensity of reflection which occurs at a wavelength where negligible absorption occurs. For example, a silver appearing article reflects substantially all visible wavelengths, whereas the introduction of a dye to achieve other metallic hues will necessarily lower reflectivity of the body at the 30 absorbing wavelengths. Wavelengths unaffected by the dye will be reflected at essentially the same intensity as a non-dyed sample, and it is at these unaffected wavelengths to which the intensity of reflection 35 pertains. With respect to transmission of light through

the body, the specific percentages reported are with respect to nonabsorbing wavelengths.

In accordance with one aspect of the invention, a multilayer reflective polymeric body of at least first and second diverse polymeric materials arranged in substantially parallel alternating layers is provided. The body has first and second major surfaces, wherein the first and second polymeric materials differ from each other in refractive index by at least 0.03. The body includes a sufficient number of layers such that the body reflects at least 40 percent of light impinging on the first major surface thereof while transmitting at least 5 percent of light directed through the body from the second major surface. Preferably, the body includes a coloring agent incorporated in or present on at least one of the first and second major surfaces such that when the body is illuminated, the body exhibits the color of the coloring agent.

The reflective polymeric body of the invention may take a variety of forms. For example, in a preferred embodiment, the polymeric body may be in the form of a film or sheet. In addition, the polymeric body may be in the form of a lighting lens for a vehicle. Further, the reflective polymeric body can be in the form of a decorative trim part for a vehicle or in the form of a housing or part of a housing for a consumer appliance such as a door or portion thereof for a refrigerator. Additionally, the reflective polymeric body of the invention may have at least one of the first and second major surfaces of the body comprising first and second portions, wherein the first portion has the coloring agent incorporated in or present thereon and the second portion is substantially transparent upon

exposure to light directed through the body from the second major surface thereof.

Further, one color on the first surface and a different color on the second surface is possible. For 5 example, a red coloring agent can be present in or on the first surface while the second surface includes a green coloring agent resulting in the polymeric body appearing red in reflection and neutral or gray upon exposure to a back light source. Similarly, different 10 color combinations on the first and second surfaces of the polymeric body, respectively, can interact to produce a third color when back lit.

A number of substantially transparent polymers 15 are suitable for use in the present invention. In a preferred embodiment, the first polymeric material may be a polyurethane and the second polymeric material may be polymethylmethacrylate. Alternatively, the first 20 polymeric material can be a polyurethane while the second polymeric material is a polyether imide. Other combinations of polymers include the combination of a polycarbonate with a miscible blend of polyvinylidene fluoride and polymethylmethacrylate, the combination of 25 polystyrene with a copolymer of ethylene and at least one unsaturated monocarboxylic acid, the combination of polystyrene with polymethylmethacrylate, and the combination of a polycarbonate with polymethylmethacrylate. 30

In certain embodiments of the invention, to obtain high reflectivity, it is desirable to form the 35 reflective polymeric body to comprise at least 500 or more layers. Increasing the total number of layers in the polymeric body has been found to increase its

reflectivity (that is, the percentage of incident light reflected from the body). Thus, by controlling the number of layers, the degree of reflectivity of the article may be controlled. Preferably, the reflectivity should not be too high so as to maintain the preferred 5 level of transmissivity, namely, at least 5 percent. It should be understood, however, that an intense light source, such as a light-emitting diode (LED), can be used as the back light source resulting in transmission 10 of light even with a polymeric body which is 95 percent reflective.

The coloring agent used in the polymeric body is preferably selected from the group consisting of 15 pigments and dyes. Metallic colors such as gold, bronze, or copper may be used. Other colors such as black, blue, red, yellow, and white may also be used. Additionally, the polymeric body may contain a second 20 coloring agent incorporated into at least one of the layers between the first and second major surfaces of the body. In this way, coloring agents may be used in combination to provide desirable coloring and optical properties. For example, a gold or other bright 25 metallic trim or lens can be produced from the polymeric body that can be illuminated to create an illuminated gold, copper, bronze decorative trim or lens. Further, a white coloring agent may be used in an interior 30 surface while a colored dye, such as blue, yellow, red, or green, may be included on one or more surface layers to provide a unique reflective colored effect.

Further, while the normal surface of the 35 polymeric body is smooth to give a highly reflective silver like appearance, in some instances it may be desirable to give the surface of the polymeric body a

roughened, grained or brushed appearance to simulate a brushed metallic appearance. Further, a solvent may be used to etch the surface of the multilayer body to provide a matte or pewter look to the polymeric body. Additionally, the polymeric body may be embossed with a 5 variety of patterns to provide desirable optical effects.

In addition, at least one surface of the polymeric body may have indicia printed thereon to illuminate information upon exposure to a back light source and to conceal such information when not exposed to light. In that regard, the polymeric body of the invention may be used in the interior of a vehicle, for example, to illuminate controls with the appearance of a chrome knob with a green label or printed indicia indicating "volume" when traveling during the night. Further, a bright exterior vehicle door trim can include text printed in or on one of the layers of the polymeric body which forms the trim so as to illuminate the 10 15 20 keyhole.

In all of the aforescribed embodiments, the particular polymers and the optical thicknesses of the 25 layers are preferably chosen such that there is an absence of visibly perceived iridescence. To that end, suitable polymer combinations and the manner in which the optical thicknesses are chosen to provide a substantially noniridescent polymeric body is set forth 30 in Wheatley et al., U.S. Patent No. 5,122,905, Wheatley, U.S. Patent No. 5,122,906, and Wheatley et al., U.S. Patent No. 5,126,880. Suitable thermoplastic resins are listed in Wheatley et al., U.S. Patent Nos. 5,122,905 35 and 5,122,906. Those listed suitable thermoplastic resins, along with representative refractive indices,

which may be used in the practice of the present invention include, but are not limited to:  
perfluoroalkoxy resins (refractive index = 1.35),  
polytetrafluoroethylene (1.35), fluorinated ethylene-  
propylene copolymers (1.34), silicone resins (1.41),  
5 polyvinylidene fluoride (1.42), polychlorotri-  
fluoroethylene (1.42), epoxy resins (1.45), poly(butyl  
acrylate) (1.46), poly(4-methylpentene-1) (1.46),  
poly(vinyl acetate) (1.47), ethyl cellulose  
10 (1.47), polyformaldehyde (1.48), polyisobutyl  
methacrylate (1.48), polymethyl acrylate (1.48),  
polypropyl methacrylate (1.48), polyethyl methacrylate  
(1.48), polyether block amide (1.49), polymethyl  
methacrylate (1.49), cellulose acetate (1.49), cellulose  
15 propionate (1.49), cellulose acetate butyrate (1.49),  
cellulose nitrate (1.49), polyvinyl butyral (1.49).  
polypropylene (1.49), polybutylene (1.50), ionomeric  
resins such as Surlyn (trademark) (1.51), low density  
polyethylene (1.51), polyacrylonitrile (1.51),  
20 polyisobutylene (1.51), thermoplastic polyesters such as  
Ecdel (trademark) (1.52), natural rubber (1.52),  
perbunan (1.52), polybutadiene (1.52), nylon (1.53),  
polyacrylic imides (1.53), poly(vinyl chloro acetate)  
25 (1.54), polyvinyl chloride (1.54), high density  
polyethylene (1.54), copolymers of methyl methacrylate  
and styrene such as Zerlon (trademark) (1.54),  
transparent acrylonitrile-butadiene-styrene terpolymer  
(1.54), allyl diglycol resin (1.55), blends of  
30 polyvinylidene chloride and polyvinyl chloride such as  
Saran resins (trademark) (1.55), polyalpha-methyl  
styrene (1.56), styrene-butadiene latexes such as Dow  
512-K (trademark) (1.56), polyurethane (1.56), neoprene  
35 (1.56), copolymers of styrene and acrylonitrile such as  
Tyril resin (trademark) (1.57), copolymers of styrene

and butadiene (1.57), polycarbonate (1.59), other thermoplastic polyesters such as polyethylene terephthalate and polyethylene terephthalate glycol (1.60), polystyrene (1.60), polyimide (1.61), polyvinylidene chloride (1.61), polydichlorostyrene (1.62), polysulfone (1.63), polyether sulfone (1.65), and polyetherimide (1.66). The refractive indices reported above may vary somewhat at different wavelengths. For example, the refractive index of polycarbonate is somewhat greater for light in the blue region of the spectrum and somewhat lower for light in the red region of the spectrum. Copolymers of the above resins are also useful such as ethylene and vinyl alcohol, styrene and hydroxy ethylacrylate, styrene and 15 maleic anhydride, styrene-butadiene block copolymers, styrene and methlymethacrylate, and styrene and acrylic acid. Other useful polymeric materials include polyetheretherketones, polybutene, maleic anhydride grafted polyolefins such as Admer (available from Mitsui 20 Chemicals) and Plexar (available from Quantum Chemicals), and copolymers of ethylene and vinyl acetate such as CXA (available from du Pont). The latter three polymers are particularly useful as adhesive layers to bond other polymeric layers together in the multilayer construction. A condition for the selection of the 25 polymers to make up the alternating layers of the body is that the polymers selected have refractive indices which differ from each other by at least about 0.03. 30 Suitable thermoplastic resins, listed in U.S.Pat, No. 5,126,880, along with representative refractive indices, which may be used in the practice of the present invention include, but are not limited to: 35 copolycarbonates of bisphenol and thiophenol (refractive index = 1.59 to 1.64), blends of polymethyl

methacrylate and vinylidene fluoride (1.42 to 1.49), bisphenol A polycarbonate (1.59), copolymers of methyl methacrylate and vinylidene fluoride, polymethyl acrylate (1.48), polymethyl methacrylate (1.49), blends and copolymers of polymethyl methacrylate and

5 polymethyl vinylidene fluoride; copolymers of vinylidene fluoride and other halogenated monomers such as chlorofluoroethylene, chlorodifluoroethylene, chlorotrifluoroethylene, chlorotrifluoroethylene, hexafluoroacetone, hexafluoropropylene, hexafluoropropene, pentafluoropropylene, trifluoroethylene, tetrafluoroethylene, and vinyl fluoride blended with polymethyl methacrylate; blends of polyvinylidene fluoride and poly(vinyl acetate); copolymers of methyl

10 methacrylate, vinylidene fluoride, and a monomer selected from the group consisting of chlorofluoroethylene, chlorodifluoroethylene, chlorotrifluoroethylene, chlorotrifluoroethylene, hexafluoroacetone, hexafluoro-propylene,

15 hexafluoropropene, pentafluoropropylene, trifluoroethylene, tetrafluoroethylene, and vinyl fluoride blended with polymethyl methacrylate; and blends of polyvinylidene fluoride and poly(vinyl acetate). The refractive indices reported above may

20 vary somewhat at different wavelengths. For example, the refractive index of polycarbonate is somewhat greater for light in the blue region of the spectrum and somewhat lower for light in the red region of the

25 spectrum. Copolymers of the above resins are also useful such as ethylene and vinyl alcohol, styrene and hydroxy ethylacrylate, styrene and maleic anhydride, styrene-butadiene block copolymers, styrene and methyl

30 methacrylate, and styrene and acrylic acid. Other useful polymeric materials include polyetheretherketones, polybutene, maleic anhydride grafted polyolefins such as

Admer (available from Mitsui Chemicals) and Plexar (available from Quantum Chemicals), and copolymers of ethylene and vinyl acetate such as CXA (available from du Pont). The latter three polymers are particularly useful as adhesive layers to bond other polymeric layers together in the multilayer construction. A condition for the selection of the polymers to make up the layers of the body is that the polymers selected have refractive indices which differ from each other by at least about 0.03. Further, the polymers should preferably be compatible in processing temperatures so that they may be readily coextruded.

Additionally, the multilayer reflective polymeric bodies of the present invention may be formed by a variety of ways. For example, the polymeric body can be formed using the extrusion die, that is, profile extrusion as described in Wheatley et al., U.S. Patent No. 5,126,880. Additionally, post-forming operations can be used which include thermoforming, vacuum forming and pressure forming. In a preferred embodiment, the polymeric body is thermoformable. Further, through the use of forming dies, the polymeric body may be initially formed into a variety of useful shapes including parts for automotive, commercial and residential lighting applications. In addition, component fabrication techniques including insert injection molding, ultrasonic welding, adhesive bonding, and other attachment and welding methods can be used to fabricate the present polymeric body into the desired part.

Another aspect of the invention is directed to the polymeric body having an image projected on a surface thereof and which can be back lit with, for example a LED (light emitting diode), to be used as a

pointer. Further, an array of light sources such as LEDs can be used in, for example, display panels, automotive decorative lamps and centered high mounted stop lamps. Preferably, this embodiment comprises a multilayer reflective polymeric body of at least first and second diverse polymeric materials arranged in substantially parallel alternating layers wherein the first and second polymeric materials differ from each other in refractive index by at least 0.03. The body 5 has first and second major surfaces wherein an image is projected onto the first major surface of the body. The body includes a sufficient number of layers such that the body reflects at least 40 percent of light impinging 10 on the first major surface thereof while transmitting at least 5 percent of light directed through the body from the second major surface so as to illuminate the image 15 on the first major surface. It should be understood that high intensity light sources such as LEDs are sufficient to penetrate polymeric bodies capable of 20 transmitting only 5 percent of light directed through the body.

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In another aspect of the invention, a colored light source is provided. A light source is enclosed by 25 a multilayered reflective polymeric sheet or film having first and second major surfaces wherein the second major surface faces the light source and the first major surface faces opposite the second major surface. The sheet or film has at least first and second diverse 30 polymeric materials arranged in substantially parallel alternating layers, the sheet or film including a coloring agent incorporated in or present on at least 35 one of the first and second major surfaces, wherein the first and second polymeric materials differ from each

other in refractive index by at least 0.03. The sheet or film includes a sufficient number of layers such that the film reflects at least 40 percent of light impinging on the first major surface thereof while transmitting at least about 5 percent of light directed through the body 5 from the second major surface such that when the body is illuminated, the polymeric body exhibits the color of the coloring agent.

Further, the present invention may find use in 10 a lamp assembly comprising a light source mounted in a housing having at least one surface in the form of a lighting lens. The lighting lens comprises at least first and second diverse polymeric materials arranged in 15 substantially parallel alternating layers. The lighting lens has first and second major surfaces wherein the second major surface faces the light source and the first major surface faces opposite the second major surface. Preferably, the lighting lens has a coloring 20 agent incorporated in or present on at least one of the first and second major surfaces, wherein the first and second polymeric materials differ from each other in refractive index by at least 0.03. The lighting lens includes a sufficient number of layers such that the 25 lighting lens reflects at least 40 percent of light impinging on the first major surface thereof while transmitting at least 5 percent of light directed through the body from the second major surface such that when the body is illuminated, the polymeric body 30 exhibits the color of the coloring agent.

In accordance with another aspect of the 35 invention, a multilayer reflective polymeric body of at least first and second diverse polymeric materials arranged in substantially parallel alternating layers

which define at least one edge of the body is provided. The body has first and second major surfaces substantially parallel to the layers, and includes a coloring agent incorporated in or present on at least one of the layers. The first and second polymeric 5 materials differ from each other in refractive index by at least 0.03, the body including a sufficient number of layers such that the body reflects at least 40 percent of light impinging on the first major surface thereof 10 while transmitting at least 5 percent of light directed through the edge of the body. Preferably, at least one of the first and second major surfaces includes irregularities thereon such that when the edge is illuminated, the body exhibits the color of the coloring 15 agent. As used herein, irregularities encompasses notches, conical dots or indentations, conical protrusions, embossments, surface abrasions or any other shaped indentation or protrusion which would render the surface other than uniformly smooth.

20 Another aspect of the invention is directed to a method for forming a reflective multilayer polymeric body having essentially no visually perceived iridescence. The method comprises the step of providing 25 a molding assembly including a mold having a face half and a corresponding core half together which define the contour of the product. The face half and the core half of the mold each have a press platen adapted to compress the face half and the core half against one another. 30 The molding assembly includes means for cushioning the mold when the face half and the core half are compressed together by the press platens to mold the product. The method further comprises the steps of inserting between 35 the face half and the core half of the mold a formable

multilayer reflective polymeric sheet having essentially no perceived iridescence, and compressing each of the press platens in the molding assembly such that the face half and the core half of the mold are compressed against the sheet while the cushioning means cushions the mold to prevent uneven flowing and thinning of the layers in the sheet or film to produce the product. Such uneven flowing and thinning in the sheet or film causes iridescence in the resulting product.

In a preferred embodiment, the cushioning means comprises an elastomeric blanket inserted between the face half and the core half of the mold. Additionally, or alternatively, the cushioning means may comprise an elastomeric blanket inserted between at least one of the press platens and the mold. Another embodiment of the present method includes the step of forming at least one of the core half and the face half from an elastomeric material to serve as the cushioning means.

Accordingly, it is an object of the invention to provide a polymeric body or film which is reflective, and yet transmits light upon exposure to a back light source for a variety of applications including automotive, commercial, and residential applications; and, it is also an object of the invention to provide a method for making such a polymeric body or film. Other objects and advantages of the invention will be apparent from the following detailed description, the accompanying drawings and the appended claims.

Fig. 1 is a fragmentary perspective view of an automobile in which the polymeric body of the invention is used in its lighting system;

Fig. 2 is a fragmentary view of the automobile shown in Fig. 1 in which the front lighting system is illuminated;

5 Fig. 3 is a cross-sectional view taken along view line 3--3 in Fig. 1 of one headlight of the automobile depicted in Figs. 1-2;

10 Fig. 4 is a partial cross-sectional view taken along view line 4--4 in Fig. 3 of the lighting lens in the headlight shown in Fig. 3;

15 Fig. 5 is a cross-sectional view of the headlight shown in Fig. 3 in which the light source is illuminated;

Fig. 6 is a fragmentary perspective view of the rear portion of an automobile in which the rear lighting system incorporates the polymeric body of the invention;

20 Fig. 7 is a fragmentary perspective view of the automobile as shown in Fig. 6 wherein the rear lighting system is illuminated;

25 Fig. 8 is a cross-sectional view taken along view line 8--8 in Fig. 6 of one half of the rear lighting system on the automobile depicted Figs. 6-7;

30 Fig. 9 is a rear elevational view of the rear lights shown in Fig. 8 in which the lights are illuminated;

35 Fig. 10 is a fragmentary perspective view of the rear portion of an automobile similar to Figs. 6 and 7 with the addition of a centrally located rear indicia display light;

Fig. 11 is a fragmentary perspective view of the automobile shown in Fig. 10 in which the indicia display light is illuminated;

5 Fig. 12 is a fragmentary perspective view of an automobile having a body side molding formed of the polymeric body wherein a light source is mounted adjacent an edge thereof for illuminating the molding;

10 Fig. 13 is a plan view of the molding depicted in Fig. 12 in which the light source is illuminated;

15 Fig. 14 is a fragmentary perspective view of a room ceiling in which a colored or uncolored (silvery) lens formed from the polymeric body is mounted;

Fig. 15 is a fragmentary perspective view as shown in Fig. 16 in which the colored lens is illuminated;

20 Fig. 16 is a perspective view of a refrigerator which includes a freezer door and a refrigerator formed from the polymeric body of the invention;

25 Fig. 17 is a perspective view of the refrigerator shown in Fig. 16 wherein an internal light has been illuminated to permit viewing of the refrigerator contents;

30 Fig. 18 is a perspective view of another embodiment in which the polymeric body has an image casted upon it while also being back lit;

35 Fig. 19 is a side elevational view of a molding assembly which is used to form the polymeric body of the invention into the desired product; and

Fig. 20 is an enlarged fragmentary side elevational view of the molding assembly shown in Fig. 18 in which the mold is compressed together to form the desired product.

5 The present invention provides a polymeric body which is reflective, and yet transmits light upon exposure to a back light source. A method for forming the polymeric body is also provided and will be discussed in detail below. Such a polymeric body finds  
10 use in a wide variety of applications including but not limited to automotive, residential and commercial applications. Those skilled in the art will appreciate the multitude of ways in which a polymeric body, which  
15 is reflective and yet transmits light upon exposure to a back light source, can be applied in various areas other than those explicitly described herein.

As stated above, the preferred polymeric body  
20 is a multilayered, reflective material comprising at least two diverse polymeric materials arranged in substantially parallel alternating layers which, in most applications, has at least two major surfaces with a coloring agent incorporated in or present on one of the  
25 major surfaces. The polymeric materials differ in refractive index by at least 0.03. Preferably, the polymeric body should comprise a sufficient number of layers such that the body reflects at least 40 percent of light impinging one of the major surfaces thereof  
30 while transmitting at least 5 percent of light directed through the polymeric body when illuminated with a back light source.

35 For most applications, it is preferred that the polymeric body has an absence of visually perceived

iridescence. In fact, it is an object of the method of the invention to form a polymeric film or sheet material which does not exhibit iridescence into a product which also does not display such iridescence. Consequently, the polymeric body of the invention should specifically 5 avoid layer thicknesses which would result in substantial iridescent color. On the other hand, alternating layers too thick to cause iridescence, in combination with layers too thin to cause iridescence, 10 result in a body which exhibits an essentially uniform silver and noniridescent appearance. This silvery appearance, which is desired for the invention, is due to higher order reflections from the optically thick layers being so closely spaced that the human eye 15 perceives the reflection to be essentially noniridescent.

There are an unlimited number of ways in which the alternating layers of the polymeric body can be 20 designed to provide this silvery appearance along with the other desired properties for use with a back light source. For example, reflective multilayer polymeric films and sheets can be formed of optically thick layers (optical thickness of greater than about 0.45  $\mu\text{m}$ ) or a 25 combination of optically thick and optically very thin layers (optical thickness of less than about 0.09  $\mu\text{m}$ ), or a combination of optically thick, optically thin (optical thickness of between 0.09 and 0.45  $\mu\text{m}$ ), and 30 optically very thin layers which exhibit a substantially colorless uniform silvery reflective appearance. Specifically, the manner in which the optical thicknesses are chosen is set forth in Wheatley et al, 35 U.S. Patent No. 5,122,905, Wheatley, U.S. Patent No. 5,122,906, and Wheatley et al, U.S. Patent No.

5,126,880. Furthermore, by introducing large layer thickness gradients into the layers, one can produce a broad band substantially uniformly reflective body.

Preferably, the polymers chosen have a refractive index mismatch of at least 0.03 at the visible wavelengths 380 to 680 nm. Typically, refractive indices of materials, including polymers, are measured at a convenient wavelength in the visible range such as 589 nm sodium vapor. As briefly stated above, several substantially transparent polymers are suitable for use in the present invention. A number of substantially transparent polymers are suitable for use in the present invention. In a preferred embodiment, the first polymeric material may be a polyurethane and the second polymeric material may be polymethylmethacrylate. Alternatively, the first polymeric material can be a polyurethane while the second polymeric material is a polyether imide.

Other combinations of polymers include the combination of a polycarbonate with a miscible blend of polyvinylidene fluoride and polymethylmethacrylate, the combination of polystyrene with a copolymer of ethylene and at least one unsaturated monocarboxylic acid, the combination of polystyrene with polymethylmethacrylate, and the combination of a polycarbonate with polymethylmethacrylate. Further, polymers and their respective refractive indices, which are useful in the practice of the present invention include all of the polymers listed in the aforementioned Wheatley et al., U.S. Patent No. 5,122,905, Wheatley, U.S. Patent No. 5,122,906, and Wheatley et al., U.S. Patent No. 5,126,880.

In accordance with another aspect of the invention, a multilayer reflective polymeric sheet and film are provided. The sheet and film, like the polymeric body, preferably comprise at least two diverse polymeric materials arranged in substantially parallel 5 alternating layers and have two major surfaces with, optionally, a coloring agent incorporated in or present on at least one of such surfaces. As briefly discussed above and in greater detail below, the coloring agent 10 can be included in the core layers of the polymeric body and/or in the skin or surface layers.

The polymeric materials are preferably those of which have been discussed above. The sheet and film 15 include a sufficient number of layers such that they each reflect at least 40 percent of light impinging on one of the major surfaces thereof while transmitting at least 5 percent of light directed through the film and sheet such that when they are illuminated, they exhibit 20 the color of the coloring agent. With the sheet and film embodiments of the invention, a multitude of additional applications are possible as those skilled in the art will appreciate.

25 Additionally, the polymeric body may contain a second coloring agent incorporated into at least one of the layers between the major surfaces of the body. In this way, coloring agents may be used in combination to provide desirable coloring and optical properties. For 30 example, a gold or other bright metallic trim or lens can be produced from the polymeric body that can be illuminated to create an illuminated gold, copper, bronze decorative trim or lens. Further, a white 35 coloring agent may be used in an interior surface while a colored dye, such as blue, yellow, red, or green, may

be included on one or more surface layers to provide a unique reflective colored effect. Different colors such as black, gray, blue, red, yellow, and white may also be used. For example, a pigmented white coloring agent may be used in an interior surface while a colored dye may 5 be included on one or more surface layers to provide a unique reflective colored effect. Other examples are discussed in detail below.

Further, while the normal surface of the 10 polymeric body is smooth to give a highly reflective specular silver appearance substantially free of iridescence in automotive styling of decorative trim and lighting, it may be desirable to give the surface of the 15 polymeric body a roughened or brushed appearance to simulate a brushed metallic appearance. Of course, other applications may also find use for such a feature. Further, a solvent may be used to etch the surface of the polymeric body to provide a matte, diffuse, or 20 pewter look to the body. Additionally, the polymeric body may be provided with textured clear coats or may be embossed with a variety of patterns to provide desirable optical effects for use in the aforementioned lighting applications.

25 Reference is now made collectively to Figs. 1-5 which illustrate several of the many applications of the polymeric body. Fig. 1 is a perspective view of an automobile 10 having a front lighting system including a 30 pair of head lights 12 and 14, a pair of turn signal lights 16 and 18, and a pair of fog lights 20 and 22. Since the lenses in head lights 12 and 14, turn signal lights 16 and 18, and fog lights 20 and 22 are all 35 formed from the polymeric body as described above, the entire front portion of automobile 10 will appear as if

it is devoid of lights. The cross-hatching in Figs. 1-5 is used to indicate the position of the lenses in the various lights only since they are indiscernible when not illuminated.

5           In Fig. 2, however, head lights 12 and 14, turn signal lights 16 and 18, and fog lights 20 and 22 are illuminated such that they are each exposed to a back light source. As seen in Fig. 2, head lights 12 and 14, turn signal lights 16 and 18, and fog lights 20 and 22  
10          transmit light so as to be operational for their intended use. Consequently, the use of the polymeric body of the invention permits head lights 12 and 14, turn signal lights 16 and 18, and fog lights 20 and 22  
15          to be indiscernible when not in use, and yet transmit light from a back light source when desired. It should be understood that the lens or lamp source will be or contain the appropriate color. Those skilled in the art, however, will appreciate that in the United States  
20          the Society of Automotive Engineers Standards and Federal Motor Vehicle Safety Standard (FMVSS) may constrict the number of possible colors for such lights, especially turn signal lights 16 and 18.

25          To provide a more detailed understanding of this application of the polymeric body, Fig. 3 illustrates a cross-sectional view of head light 14 taken along view line 3--3 in Fig. 1, while Fig. 5 is a cross-sectional view of head light 14 in Fig. 2.  
30          Referring specifically to Fig. 3, head light 14 is depicted in the form of a lamp assembly comprising a light source 24 mounted in a housing 26 having a lighting lens 28. The lighting lens 28 of head light 14  
35          preferably comprises the polymeric body of the invention. Accordingly, as in Fig. 1, light is shown to

be reflected from the polymeric body since light source 24 is not illuminated. Those skilled in the art should understand that housing 26 and lighting lens 28 may be designed to shapes and contours other than those depicted herein. As seen in Fig. 3, light L including ambient light as well as light from other sources is reflected off of lens 28 when light source 24 is not illuminated.

Fig. 4 illustrates a cross-sectional view of the lighting lens 28 taken along view line 4--4 in Fig. 3. As depicted in Fig. 4, lighting lens 28 comprises the polymeric body having at least two diverse polymeric materials arranged in substantially parallel alternating layers, collectively designated by reference numeral 30. The polymeric body, which is in the form of lighting lens 28, has two major surfaces 32 and 34 upon which light is either reflected or transmitted. Optionally, a coloring agent can be incorporated in the various layers 30 and/or be present on one or both of the major surfaces 32 and 34 of lighting lens 28 so as to emit a colored light, for example, an amber dye or pigment for turn signal lights 16 and 18 shown in Fig. 2. Fig. 4 depicts a pair of cap layers 33 and 35 which may also include a coloring agent for similar purposes.

Reference is now made to Fig. 5 which depicts head light 14 when light source 24 is illuminated whereby light L therefrom is transmitted. The polymeric body which is in the form of lighting lens 28 preferably transmits at least about 5 percent, and preferably in a range from 40 to 60 percent, of the light directed from light source 24 so as to operate as a typical head light for a vehicle. It should be understood that without the inclusion of a coloring agent, the lighting lens 28 will

appear to be transparent upon illumination which is typical of most lenses in a head light lamp assembly.

Figs. 6 and 7 illustrate the rear portion of automobile 10 wherein the rear lighting system 5 incorporates the polymeric body of the invention. While the observer will perceive the rear portion of automobile 10 to have a uniform reflective appearance, there may be at least three different mounted light assemblies each having a different color when 10 illuminated. By way of example, Fig. 6 depicts a pair of brake lights 36 and 38, a pair of turn signal lights 40 and 42, and a pair of reverse lights 44 and 46. As seen in Fig. 6, each of these lights is reflective when 15 not illuminated and designed to be indiscernible. Fig. 7, however, shows brake light 36, turn signal light 40 and reverse light 44 when they are all illuminated from a back light source. Consequently, by using the polymeric body of the invention, automobile stylists and 20 designers are provided with increased design degrees of freedom.

Referring now to Fig. 8, a cross-sectional view taken along view line 8--8 in Fig. 6 is presented. Fig. 25 8 shows brake light 36, turn signal light 40 and reverse light 44 as depicted in Fig. 6 for purposes of providing a better understanding of the manner in which the polymeric body forms such parts. Brake light 36 comprises a light source 48 mounted within a housing 50 while the polymeric body forms a lighting lens 52 through which light is transmitted. As those skilled in the art will appreciate, the coloring agent used in 30 lighting lens 52 should be a red dye or pigment so that 35 brake light 36 emits a red light as depicted in Fig. 9. Alternatively, the light source 48 can be the

appropriate color. Similarly, turn signal light 40 includes its own housing 54 to separate a light source 56 from light source 48 in housing 50.

5 The polymeric body is used to form a lighting lens 58 for turn signal light 40, as well. A yellow (amber) coloring agent, such as a yellow (amber) dye or pigment, can be included in lighting lens 58 so that a yellow light is transmitted upon illumination of light source 56 as shown in Fig. 9. If the entire lens piece 10 as shown in Figs. 8 and 9 is formed as a single piece, then the various colors can be appropriately placed by using thermoformable silk-screening inks. On the other hand, if the various lenses are individual pieces as 15 presently shown, the dyes and pigments discussed above can be used.

Finally, reverse light 44 also includes a housing 60 within which a light source 62 is mounted for 20 illumination of lighting lens 64 which is formed from the polymeric body of the invention. Typically, lighting lens 64 will not include a coloring agent since reverse lights are white or colorless. Thus, upon 25 illumination of light source 62, light is transmitted through lighting lens 64 which is transparent upon illumination as shown in Fig. 9. It should be understood that lighting lenses 52, 58 and 64 can be styled so that they mesh into one another so as to form 30 a smooth contour along the rear portion of automobile 10. Further, the aforementioned lighting lenses are designed to have the same appearance and color as adjacent portions of the automobile so that they are 35 indiscernible to the casual observer.

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Reference is now made to Figs. 10 and 11 which illustrate another embodiment of the invention. Figs. 10 and 11 show automobile 10' having a rear lighting assembly similar to that of which is shown in Figs. 6-9 wherein an additional lighting lens 66 abridges the 5 various lights and includes a back light source (not shown). The polymeric body of the invention is used to form lighting lens 66 in which at least one of the major surfaces thereof has indicia 68 printed thereon. Those skilled in the art will appreciate the multitude of 10 markings (indicia) which may be printed or otherwise affixed to lighting lens 66 formed of the polymeric body. The indicia 66, for example, may be insert molded, embossed, or etched thereon.

15 In addition to other possible indicia, the polymeric body may be used for purposes other than automotive in which indicia is concealed in the polymeric body yet displayed upon illumination of a back light source. For example, the polymeric body of the 20 invention may be used in the interior of a vehicle, for example, to illuminate controls with the appearance of a chrome knob with a green label or printed markings indicating "volume" when traveling during the night. In 25 the present case, however, Fig. 11 illustrates indicia 68 indicative of the style of automobile 10' which is displayed upon illumination from a back light source.

30 Figs. 12 and 13 illustrate yet another embodiment of the invention in which the polymeric body is used to provide decorative trim which can be illuminated by a side light source. More specifically, 35 the polymeric body is in the form of a body side molding 70 having an edge 72 adjacent which a light source 74 is mounted. The side molding 70 includes a plurality of

irregularities collectively designated by reference numeral 73 which are necessary for transmitting light peripherally. Such irregularities 73 may take a variety of forms including but not limited to notches, conical dots or indentations, conical protrusions, embossments 5 or any other shaped indentation or protrusion which would render the surface of side molding 70 other than uniformly smooth.

As seen in Fig. 13, light source(s) 74 is 10 mounted in the side panel of automobile 10" so as to be concealed. When the lighting system for automobile 10" is turned on, light source 74 illuminates side molding 70 and therefore the polymeric body, which in turn, 15 transmits light from light source 74. In this way, side molding 70 is illuminated with the other lights on automobile 10" so as to illuminate the automobile further for aesthetic as well as safety purposes. A coloring agent can be incorporated in or present on at 20 least one of the layers in side molding 70 to allow stylists and designers to add automotive body style options.

It should be understood by those skilled in the 25 art that a light source positioned adjacent an edge of the polymeric body of the invention in a form other than that of which is described herein can be used to illuminate the major faces thereof. Such a feature of the polymeric body may be found in a variety of areas in 30 addition to decorative trim on an automobile. As mentioned above, residential and commercial lighting applications can use side lighting to conceal the light source at one end of the polymeric body which is in the 35 form of a lighting lens. Such a feature of the polymeric body increases the styling design options in

residential and commercial lighting applications, as well. Additionally, the polymeric body of this embodiment may also be back lit to increase design options in all of the aforementioned applications.

5 Referring now collectively to Figs. 14 and 15, another environment in which the polymeric body of the invention can be used is shown. Fig. 14 is a fragmentary perspective view of a colored lens 76 (also referred to in the art as a refractor or diffuser) 10 mounted in a ceiling 78 for commercial or residential lighting purposes. As shown, lens 76 has a reflective appearance which can be rendered indiscernible when ceiling 78 is formed of a similar reflective material as 15 oftentimes found in commercial lighting applications. Upon illumination, lens 76 provides the room in which it is mounted with light, with or without color.

20 In a preferred embodiment, lens 76 comprises a light source (not shown) enclosed by the polymeric body in the form of a sheet or film having at least two major surfaces wherein the one major surface faces the light source and the other major surface faces opposite thereto. As discussed with the previous embodiments, a 25 coloring agent can be incorporated in or present on at least one of the major surfaces of the polymeric sheet or film such that colored light is emitted through lens 76 upon illumination of the light source (not shown). Other environments in which lens 76 may be incorporated 30 are possible without departing from the scope of the invention.

35 Reference is made to Figs. 16 and 17 which illustrate another application of the polymeric body of the invention to consumer appliances and durable goods.

Fig. 16 shows a perspective view of a refrigerator 80 having a refrigerator door 82 and a freezer door 84. The polymeric body of the invention may form the entire refrigerator door 82 and freezer door 84. By providing refrigerator 80 with refrigerator door 82 and freezer door 84 made from the polymeric body, a user can view its contents 86 by merely illuminating a light source in refrigerator 80 with, for example, a foot switch 88 or other sensor device. As a result, one can view contents 86 as shown in Fig. 17 without opening either of refrigerator door 82 or freezer door 84, thereby resulting in substantial energy savings. Optionally, only a portion of refrigerator door 82 and/or freezer door 84 can be formed from the polymeric body for such purposes.

Fig. 18 depicts the image projection embodiment of the present invention. Specifically, this embodiment is directed to the polymeric body in the form of a sheet 81 having an image 83 projected on a surface thereof and which can be back lit with a light source 85. The image 83 is shown to be a map but virtually any image can be projected onto sheet 81 by means of a projector or the like (not shown). The light source 85 can be in the form of, for example, a LED or array of LEDs, which can be used as a pointer. Preferably, sheet 81 of this embodiment comprises a multilayer reflective polymeric body as described in detail above. By way of example, sheet 81 can include a grid patterned backing 87 to provide a grid superposed against image 83 upon illumination of light source 85. In this way, the versatility of this embodiment is increased, for example, in the area of instruction or display as depicted in Fig. 18. Additionally, sheet 81 can be

designed to be transparent upon illumination with a back light source yet reflect image 83 so that it will appear to an observer that image 83 is floating in flow space. Those skilled in the art will appreciate the unlimited ways in which sheet 81 and image 83 can be modified for 5 use in other applications.

The present invention also provides a preferred method by which the polymeric body can be formed into the desired product for the above-referenced 10 applications, all of which have essentially no perceived iridescence. As is the case with most products, some of which are described above, there is a need for high surface fidelity, for example, sharp details, surface 15 texturing and embossed patterns, which leads to the need for high clamp tonnages in the molding process. Conventional compression molding or thermoforming methods impart high levels of internal stress into the products formed from the polymeric body or film of the 20 invention. Additionally, conventional molding techniques have caused uneven flowing and thinning of the various layers in the polymeric body or film. All of this results in a product having undesirable 25 iridescence. The present method maintains the noniridescent property of the polymeric body or film in the final product.

The method contemplates forming the polymeric body of the invention into a variety of useful parts by thermoforming a sheet of the reflective material. Fig. 30 20 depicts a molding assembly 90 to illustrate the method of the invention which thermoforms a reflective polymeric sheet 91 into the desired product. For 35 purposes of clarity, details of molding apparatus unnecessary to an understanding of the invention have

been omitted from Fig. 20. However, those skilled in the art will appreciate that such known features of conventional molding apparatus may be used without departing from the scope of the invention.

5        The method comprises the step of providing molding assembly 90 including a mold, collectively referenced as 92, having a face half 94 and a corresponding core half 96 together which define the contour of the product. Face half 94 and core half 96  
10      of mold 92 each have a press platen 98 and 100, respectively, adapted to compress face half 94 and core half 96 against one another. Preferably, molding assembly 90 includes means for cushioning mold 92 when  
15      face half 94 and core half 96 are compressed together by press platens 98 and 100 to mold the product.

20        In a preferred embodiment, the cushioning means comprises an elastomeric blanket 102 inserted between face half 94 and core half 96 of mold 92, and specifically, between the polymeric sheet 91 and face half 94 as shown in phantom lines. In addition to, or in place of, elastomeric blanket 102, an elastomeric blanket 104 can be inserted between polymeric sheet 91  
25      and core half 96 also shown in phantom lines. Additionally, or alternatively, the cushioning means may comprise an elastomeric blanket 106 inserted between press platen 98 and mold 92. In a similar fashion, an elastomeric blanket 108 can be inserted between press  
30      platen 100 and mold 92. Additionally, the present method may include the step of forming at least one of core half 96 and face half 94 from an elastomeric material to serve as additional or alternative  
35      cushioning means.

The method further comprises the steps of inserting between face half 94 and core half 96 of mold 92 polymeric sheet 91 having essentially no perceived iridescence, and compressing each of press platens 98 and 100 in molding assembly 90 such that face half 94 and core half 96 of mold 92 are compressed against polymeric sheet 91 while any one of elastomeric blankets 102, 104, 106 or 108 cushions mold 92 to prevent uneven flowing and thinning of the layers in polymeric sheet 91 to produce the desired product. The present method facilitates alignment of the part to be formed, especially in less expensive and sophisticated molds, and also allows for larger engineering tolerances.

Fig. 20 is an enlarged fragmentary cross-sectional view of polymeric sheet 91 having elastomeric blanket 102 included to serve as the cushioning means. As shown in Fig. 20, polymeric sheet 91 maintains their uniformity with the aid of elastomeric blanket 102 as face half 94 and core half 96 are compressed together. Suitable materials which can be used for elastomeric blanket 102 include high temperature silicone rubber and other high temperature rubber materials. It should be understood that additional cushioning means such as elastomeric blanket 104 may be included without departing from the scope of the invention.

In accordance with another embodiment of the invention, a present method for making a reflective multilayer polymeric product having essentially no iridescence is provided whereby an elastomeric blanket is not inserted into molding assembly 90. Rather, at least one of face half 94 and core half 96 is formed of an elastomeric material so as to cushion mold 92 when face half 94 and core half 96 are compressed together to

5 mold the desired product. This method, although similar to the previous embodiment, provides a method by which the insertion of an elastomeric blanket is not necessary. The remaining forming steps are the same as previously described in that polymeric sheet 91 having  
10 essentially no perceived iridescence is inserted between face half 94 and core half 96 of mold 92, and each of press platens 98 and 100 in molding assembly 90 are compressed such that face half 94 and core half 96 are compressed against polymeric 91 sheet while the elastomeric material in either of face half 94 or core half 96 cushions mold 92 to prevent uneven flowing and thinning.

15 With the present invention, a polymeric body which is reflective, and yet transmits light upon exposure to a back light source is provided which can be used for a variety of applications including automotive, commercial, and residential lighting. The invention  
20 also provides a preferred method for making the polymeric body such that it retains its noniridescent properties in the ultimate product into which it is thermoformed.

25 Having described the invention in detail and by reference to preferred embodiments thereof, it will be apparent that modifications and variations are possible without departing from the scope of the invention which is defined in the appended claims. For example,  
30 applications and environments in which the polymeric body is used other than those described herein are possible without departing from the scope of the invention.

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補充AMENDED CLAIMS OF PATENT APPLN. NO. 82109102  
DATE OF AMENDMENT: December 15, 1994

1. A multilayer reflective polymeric body of at least first and second diverse polymeric materials arranged in substantially parallel alternating layers, the body having first and second major surfaces, characterized in that the first and second polymeric 5 materials differ from each other in refractive index by at least 0.03, the body including a sufficient number of layers so that the body reflects at least 40 percent of light impinging on the first major surface thereof while transmitting at least 5 percent of light directed 10 through the body from the second major surface.

2. The reflective polymeric body of Claim 1 further including a coloring agent incorporated in or 15 present on at least one of the first and second major surfaces such that when the body is illuminated, the body exhibits the color of the coloring agent.

3. The reflective polymeric body of Claim 2 20 wherein the coloring agent is selected from the group consisting of pigments and dyes.

4. The reflective polymeric body of Claim 1 25 wherein the first polymeric material is a polyurethane and the second polymeric material is polymethyl-methacrylate.

5. The reflective polymeric body of Claim 1 30 wherein that the first polymeric material is a polyurethane and the second polymeric material is a polyether imide.

6. The reflective polymeric body of Claim 1 35 wherein the first polymeric material is a polycarbonate and the second polymeric material is a

miscible blend of polyvinylidene fluoride and polymethylmethacrylate.

7. The reflective polymeric body of Claim 1  
wherein the first polymeric material is  
5 polystyrene and the second polymeric material is a  
copolymer of ethylene and at least one unsaturated  
monocarboxylic acid.

10. The reflective polymeric body of Claim 1  
wherein the first polymeric material is  
polycarbonate and the second polymeric material is a  
15 polymethyl-methacrylate.

15. The reflective polymeric body of Claim 1  
wherein at least one of the first and  
second major surfaces has a brushed, grained or  
roughened surface.

20. The reflective polymeric body of Claim 1  
wherein at least one of the first and  
second major surfaces has been etched to provide a  
matte, diffuse, or pewter finish.

25. The reflective polymeric body of Claim 1  
wherein at least one of the first and  
second major surfaces has been embossed.

30. The reflective polymeric body of Claim 1  
wherein the first and second polymeric  
materials are absent of visibly-perceived iridescence.

35. The reflective polymeric body of Claim 1  
wherein at least one of the first and  
second major surfaces has indicia printed thereon.

14. The reflective polymeric body of Claim 1  
wherein the body comprises at least 500  
layers.

5 15. The reflective polymeric body of Claim 1  
wherein the body is thermoformable.

16. The reflective polymeric body of Claim 1  
further including a coloring agent is incorporated into  
at least one of the layers between the first and second  
10 major surfaces of the body.

17. The reflective polymeric body of Claim 1  
wherein a substantial majority of the  
layers of the body have optical thicknesses in the range  
15 where the sum of the optical thicknesses in a repeating  
unit of the first and second polymeric materials is  
greater than about 190 nm.

18. The reflective polymeric body of Claim 1  
20 wherein the body is in the form of a lens.

19. The reflective polymeric body of Claim 1  
characterized in that the body is in the form of a  
decorative trim component for a vehicle.

25 20. The reflective polymeric body of Claim 1  
wherein the body forms a portion of a  
consumer appliance.

30 21. The reflective polymeric body of Claim 1  
wherein the body forms a portion of a  
surface of a refrigerator door.

35 22. The reflective polymeric body of Claim 1  
wherein at least one of the first and  
second major surfaces of the body comprises first and

second portions, wherein . . . the first portion has the coloring agent incorporated in or present thereon and the second portion is substantially transparent upon exposure to light directed through the body from the second major surface thereof.

20           24. A multilayer reflective polymeric film  
having at least first and second diverse polymeric  
materials arranged in substantially parallel alternating  
layers, the film having first and second major surfaces,  
25 characterized in that the first and second polymeric  
materials differ from each other in refractive index by  
at least 0.03, the film including a sufficient number of  
layers such that the film reflects at least 40 percent  
30 of light impinging on the first major surface thereof  
while transmitting at least 5 percent of light directed  
through the film from the second major surface.

25. The reflective polymeric film of Claim 24  
35 further including a coloring agent incorporated in or  
present on at least one of the first and second major

surfaces such that when the film is illuminated, the film exhibits the color of the coloring agent.

26. A light source enclosed by a multilayered reflective polymeric sheet having first and second major 5 surfaces characterized in that the second major surface faces the light source and the first major surface faces opposite the second major surface, the sheet having at least first and second diverse polymeric materials arranged in substantially parallel alternating layers, 10 the film including a coloring agent incorporated in or present on at least one of the first and second major surfaces, wherein — the first and second polymeric materials differ from each other in refractive 15 index by at least 0.03, the sheet including a sufficient number of layers such that the sheet reflects at least 40 percent of light impinging on the first major surface thereof while transmitting at least 5 percent of light directed through the sheet from the second major surface 20 so that when the sheet is illuminated, the sheet exhibits the color of the coloring agent.

27. The light source of Claim 26 wherein the light source is a light-emitting diode.

25 28. A lamp assembly comprising a light source mounted in a housing having at least one surface in the form of a lighting lens, characterized in that the lighting lens comprises at least first and second 30 diverse polymeric materials arranged in substantially parallel alternating layers, the lighting lens having first and second major surfaces characterized in that the second major surface faces the light source and the 35 first major surface faces opposite the second major surface, the lighting lens having a coloring agent

incorporated in or present on at least one of the first  
and second major surfaces, wherein the  
first and second polymeric materials differ from each  
other in refractive index by at least 0.03, the lighting  
lens including a sufficient number of layers such that  
5 the lighting lens reflects at least 40 percent of light  
impinging on the first major surface thereof while  
transmitting at least 5 percent of light directed  
through the lighting lens from the second major surface  
so that when the lighting lens is illuminated, the  
10 lighting lens exhibits the color of the coloring agent.

29. A multilayer reflective polymeric body of at  
least first and second diverse polymeric materials  
15 arranged in substantially parallel alternating layers  
which define at least one edge of the body, the body  
further having first and second major surfaces  
substantially parallel to the layers, the body including  
a coloring agent incorporated in or present on at least  
20 one of the layers, characterized in that the first and  
second polymeric materials differ from each other in  
refractive index by at least 0.03, the body including a  
sufficient number of layers such that the body reflects  
at least 40 percent of light impinging on the first  
25 major surface thereof while transmitting at least 5  
percent of light directed through the edge of the body,  
at least one of the first and second major surfaces  
includes irregularities thereon so that when the edge is  
30 illuminated, the body exhibits the color of the coloring  
agent.

30. A method for making a reflective multilayer  
polymeric product having essentially no perceived  
35 iridescence characterized by:

providing a molding assembly including a mold having a face half and a corresponding core half together which define the contour of the product, the face half and the core half each having a press platen adapted to compress the face half and the core half against one another, the molding assembly further including means for cushioning the mold when the face half and the core half are compressed together by the press platens to mold the product;

10 inserting between the face half and the core  
half of the mold a formable multilayer reflective  
polymeric sheet having essentially no perceived  
iridescence; and

15 compressing each of the press platens in the  
molding assembly such that the face half and the core  
half of the mold are compressed against the sheet while  
the cushioning means cushions the mold to prevent uneven  
20 flowing and thinning of the layers in the sheet to  
produce the product.

31. The method for making the reflective  
polymeric product of Claim 30 wherein the  
cushioning means comprises an elastomeric blanket  
inserted between the face half and the core half of the  
mold.

32. The method for making the reflective  
polymeric product of Claim 30 wherein the  
cushioning means comprises an elastomeric blanket  
inserted between at least one of the press platens and  
the mold.

35                   33. The method for making the reflective  
polymeric product of Claim 30           wherein           the

step of providing the molding assembly comprises the step of forming at least one of the core half and the face half from an elastomeric material.

34. The method for making the reflective  
5 polymeric product of Claim 31 wherein the  
sheet comprises at least first and second diverse  
polymeric materials arranged in substantially parallel  
alternating layers, the sheet having first and second  
major surfaces with a coloring agent incorporated in or  
10 present on at least one of the first and second major  
surfaces, wherein the first and second  
polymeric materials differ from each other in refractive  
index by at least 0.03, the sheet including a sufficient  
15 number of layers such that the sheet reflects at least  
40 percent of light impinging on the first major surface  
thereof while transmitting at least 5 percent of light  
directed through the sheet from the second major surface  
such that when the sheet is illuminated, the sheet  
20 exhibits the color of the coloring agent.

35. A method for making a reflective multilayer  
polymeric product having essentially no iridescence  
characterized by:

25 providing a molding assembly including a  
mold having a face half and a corresponding core half  
together which define the contour of the product, the  
face half and the core half each having a press platen  
30 adapted to compress the face half and the core half  
against one another, at least one of the face half and  
the core half being formed of an elastomeric material so  
as to cushion the mold when the face half and the core  
35 half are compressed together to mold the product;

inserting between the face half and the core half of the mold a formable multilayer reflective polymeric sheet having essentially no perceived iridescence; and

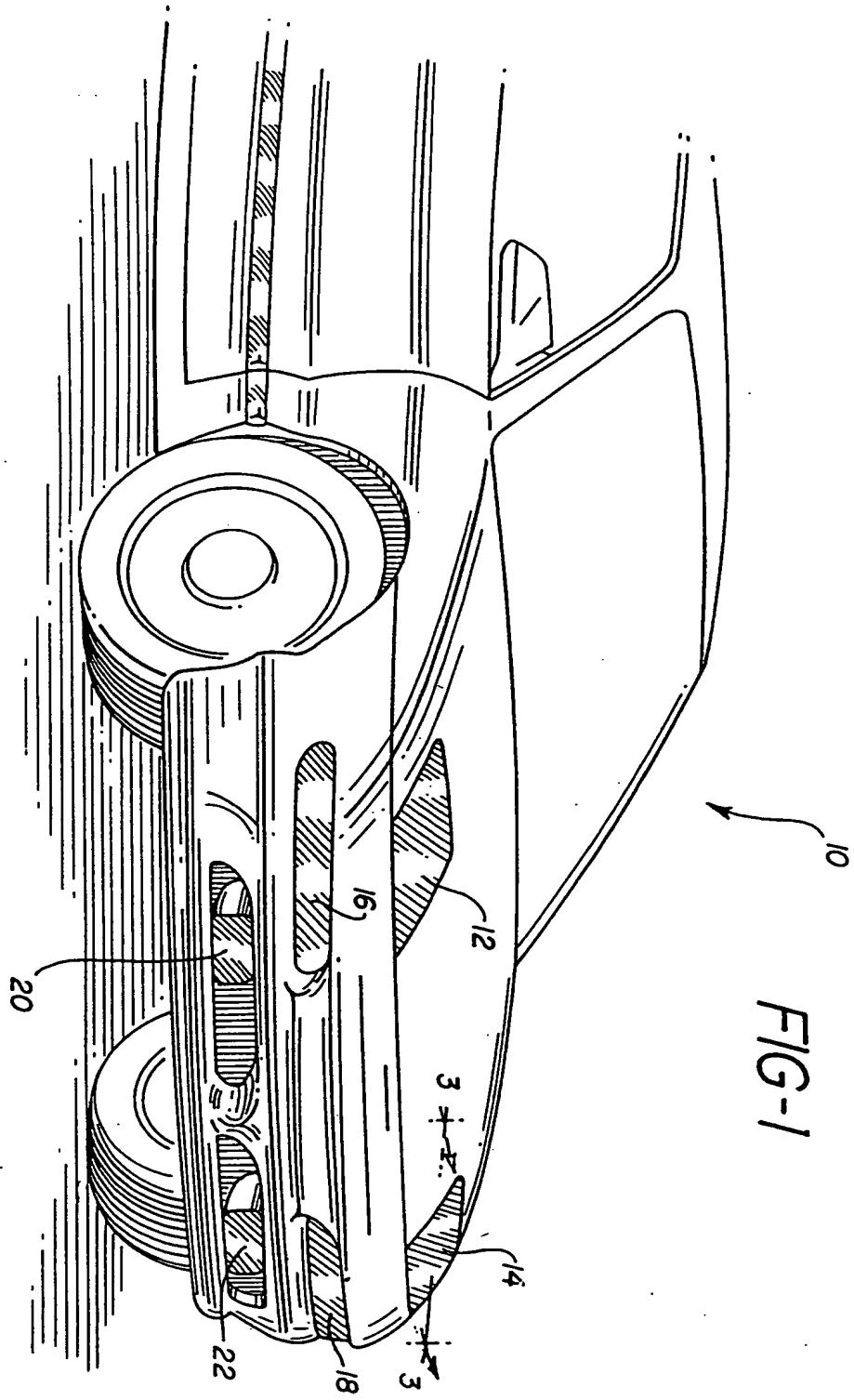
5 compressing each of the press platens in the molding assembly such that the face half and the core half of the mold are compressed against the sheet while the cushioning means cushions the mold to prevent uneven flowing and thinning of the layers in the sheet to  
10 produce the product.

36. The method for making the reflective polymeric product of Claim 35 wherein the sheet comprises at least first and second diverse  
15 polymeric materials arranged in substantially parallel alternating layers, the sheet having first and second major surfaces with a coloring agent incorporated in or present on at least one of the first and second major surfaces, wherein the first and second  
20 polymeric materials differ from each other in refractive index by at least 0.03, the sheet including a sufficient number of layers such that the sheet reflects at least 40 percent of light impinging on the first major surface  
25 thereof while transmitting at least 5 percent of light directed through the sheet from the second major surface such that when the sheet is illuminated, the sheet exhibits the color of the coloring agent.



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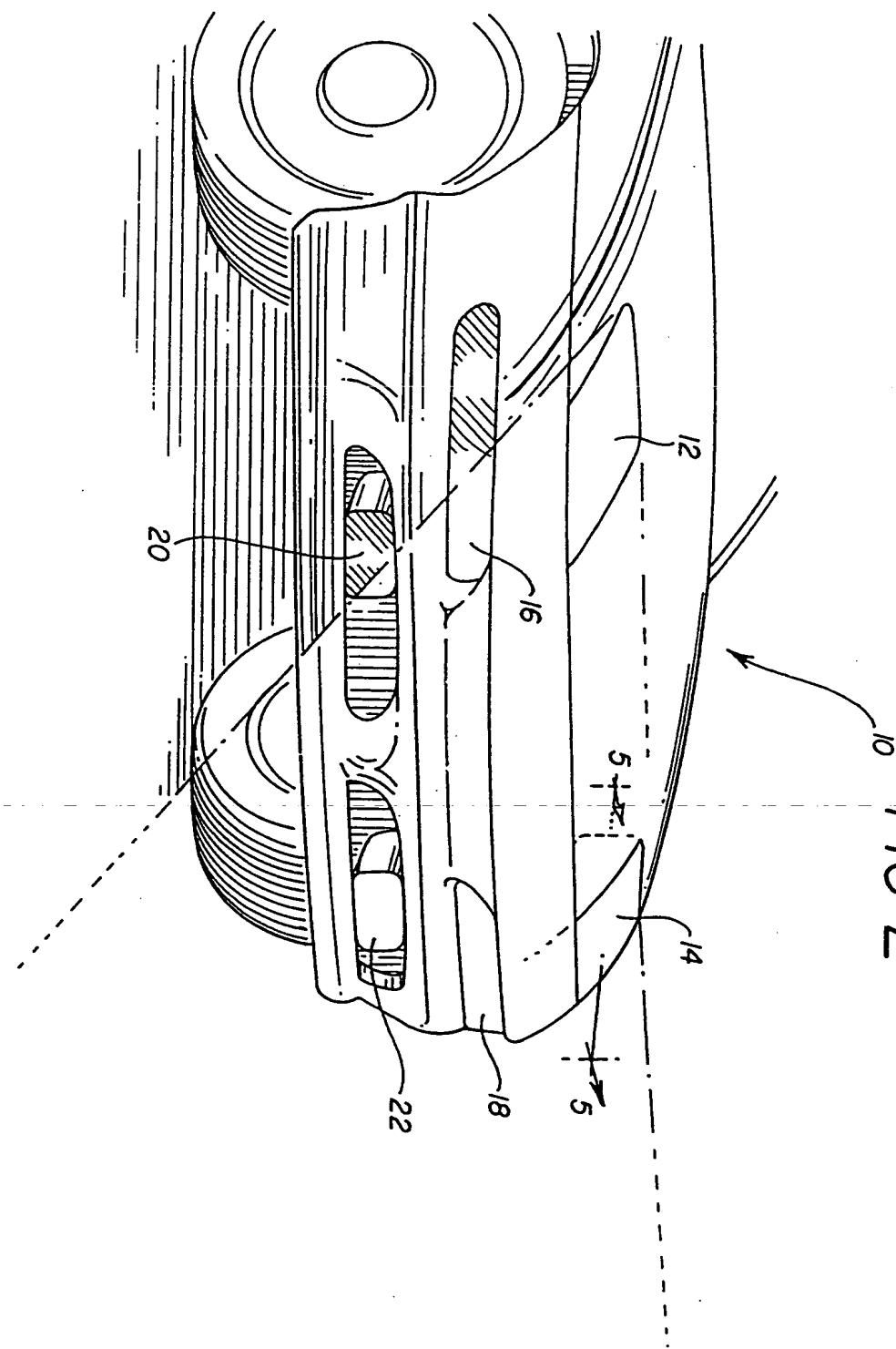


FIG-2

FIG-3

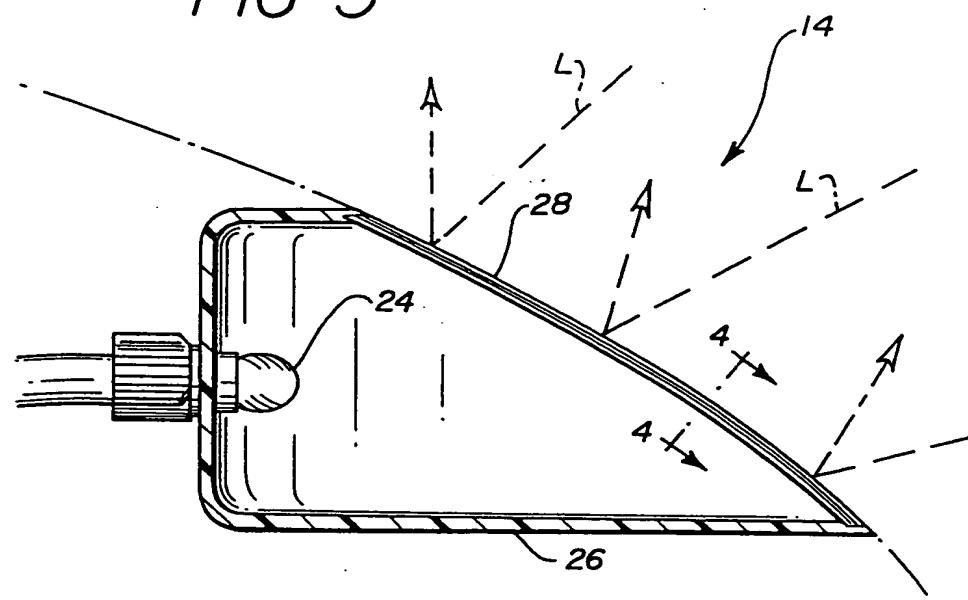


FIG-4

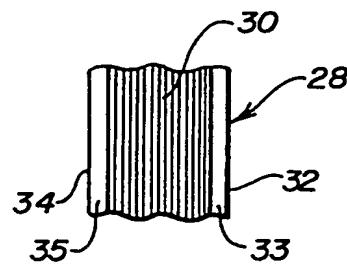


FIG-5

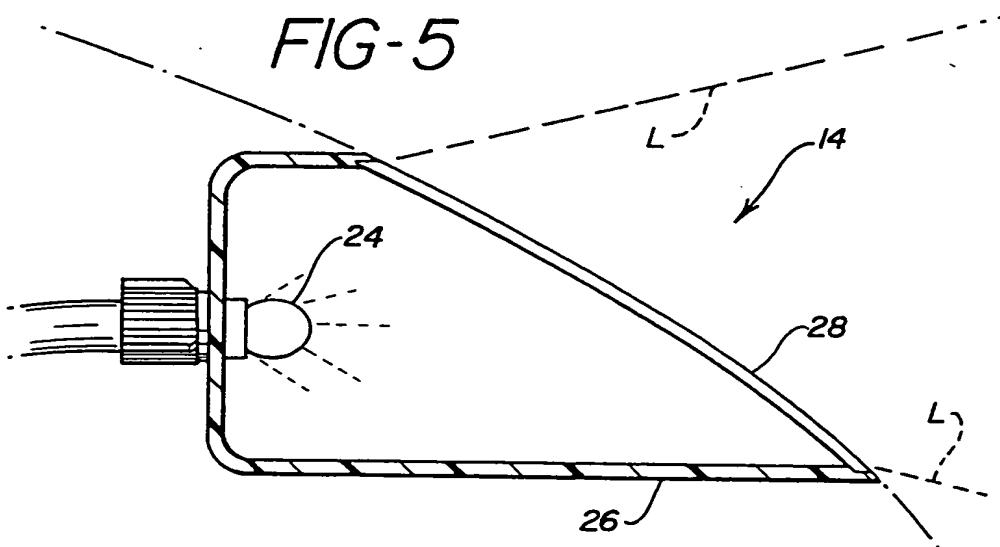


FIG-6

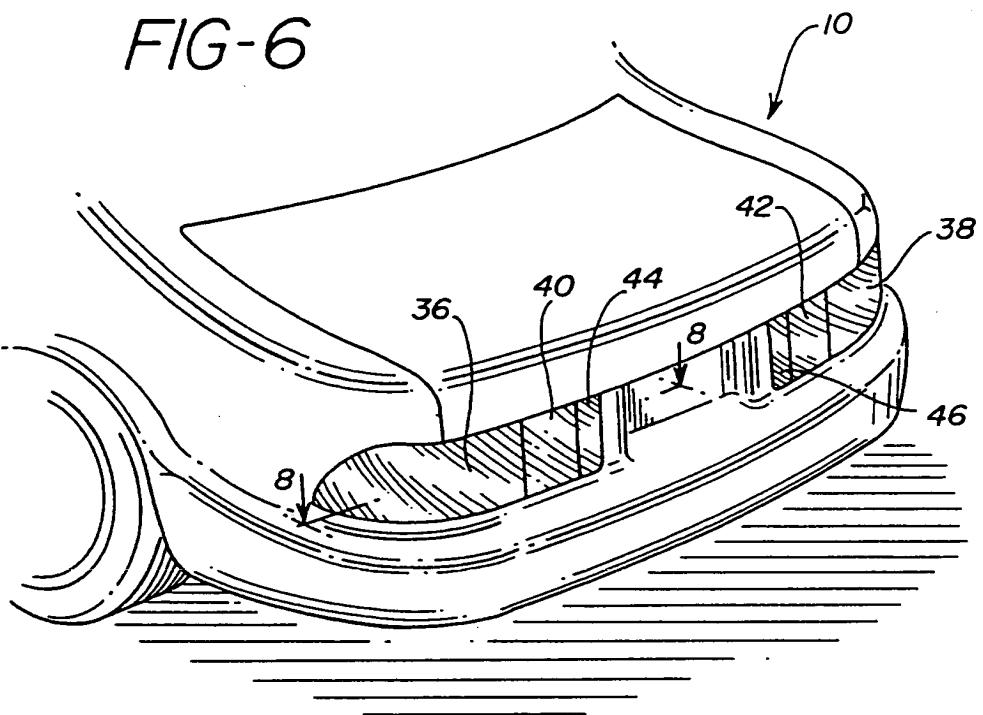


FIG-7

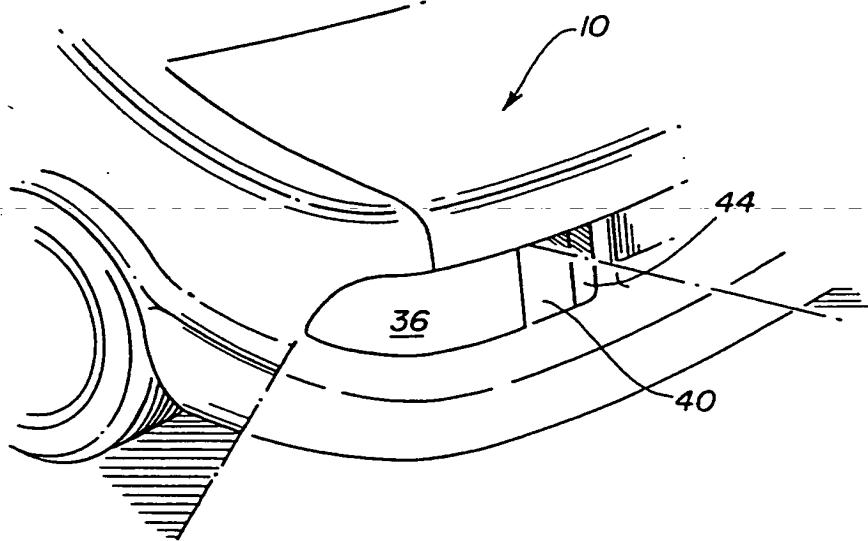


FIG-8

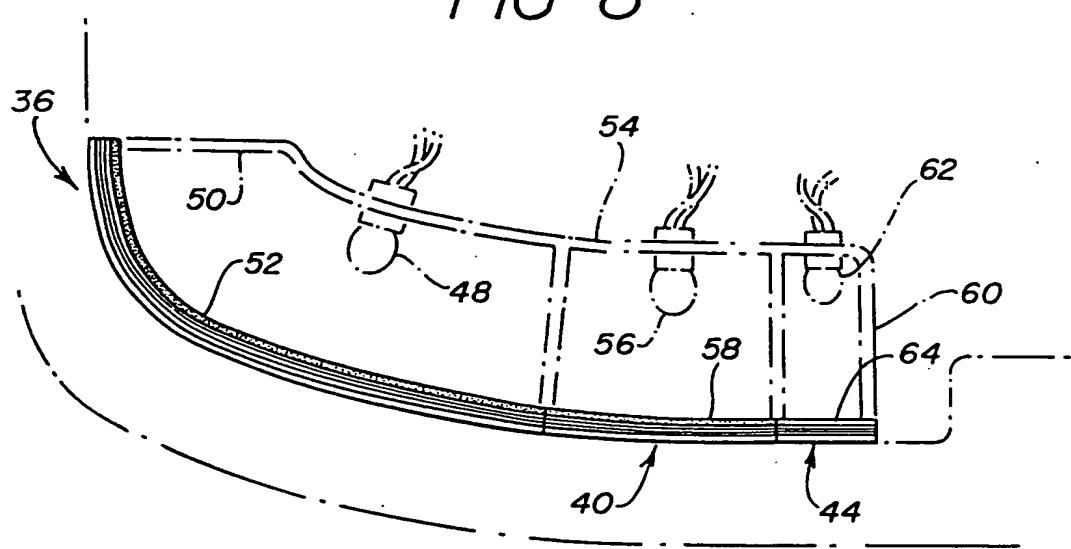
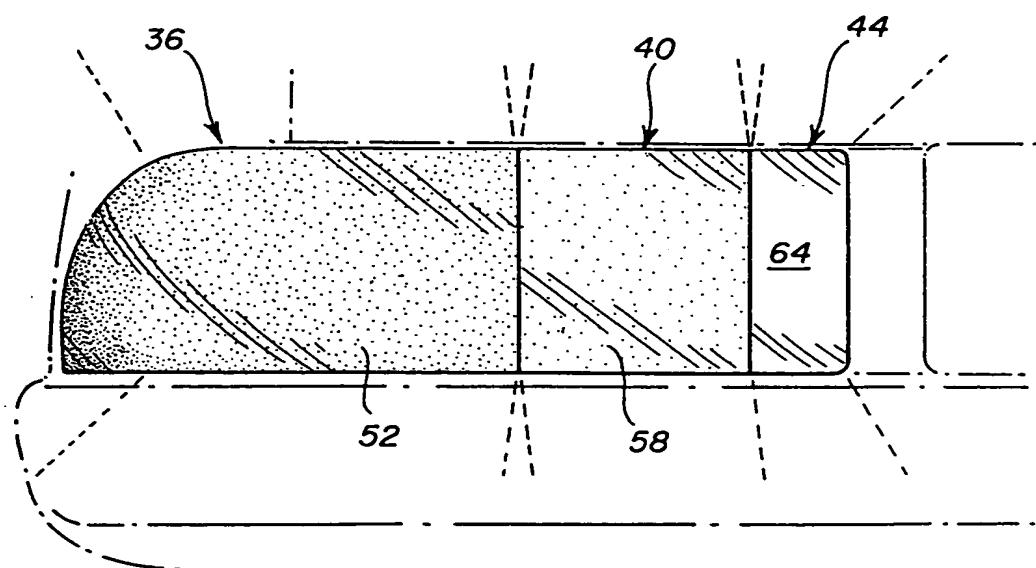
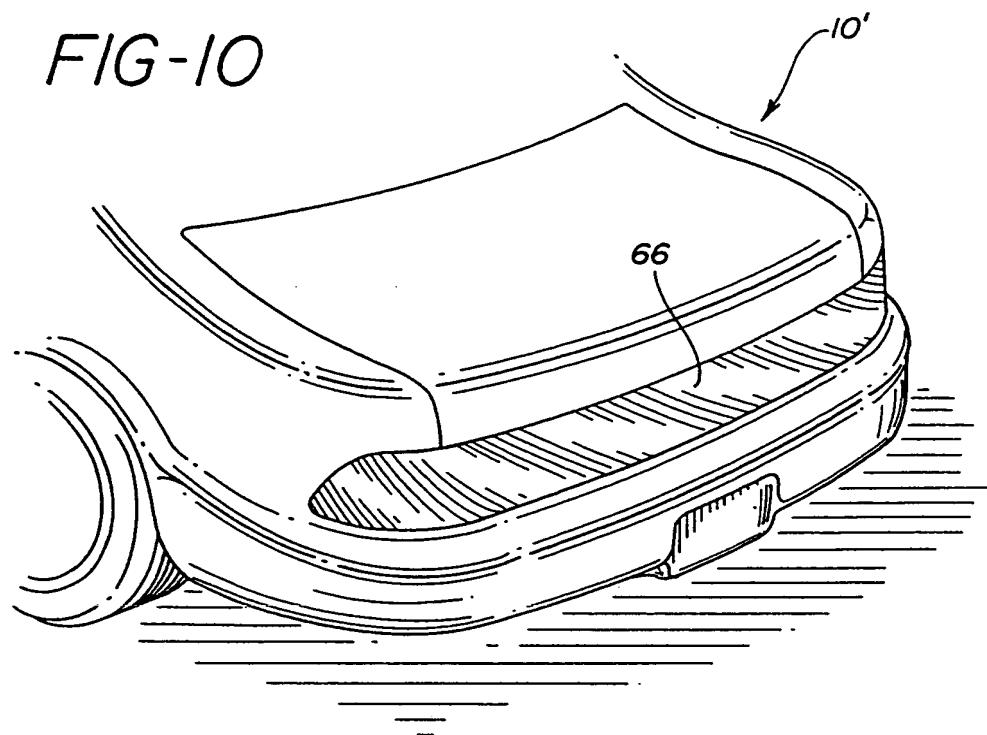


FIG-9



*FIG-10*



*FIG-11*

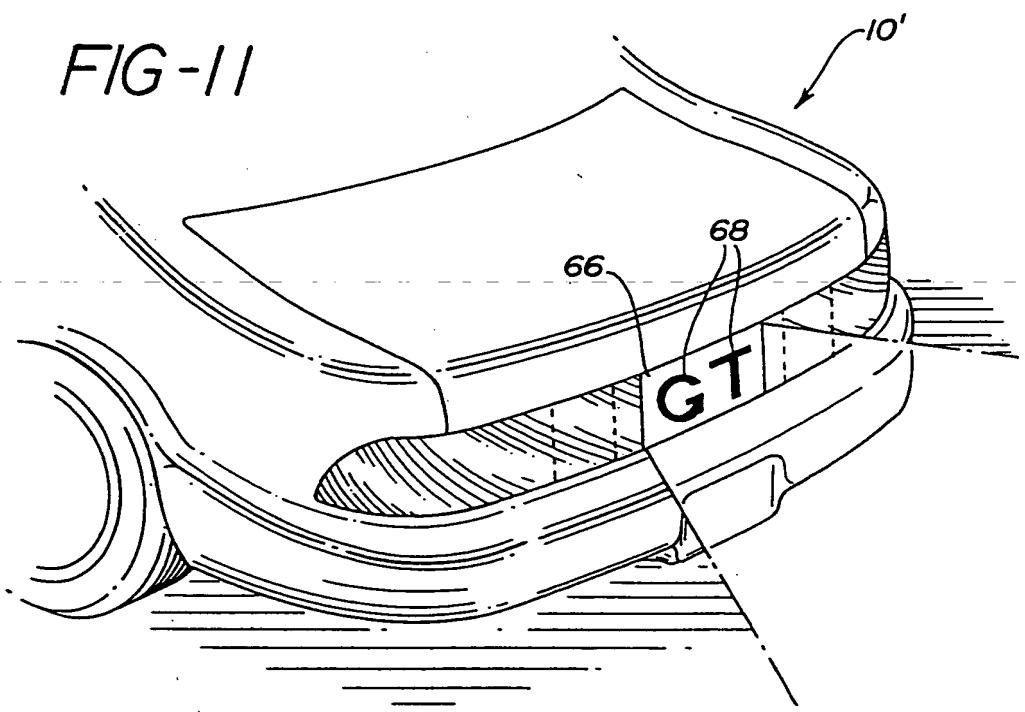


FIG-12

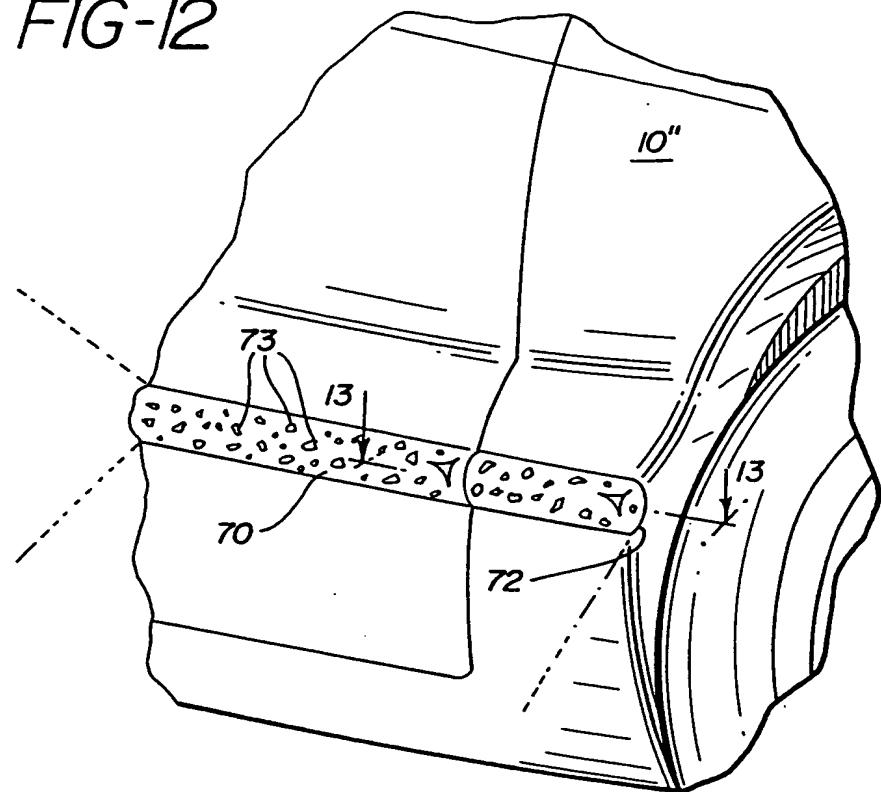


FIG-13

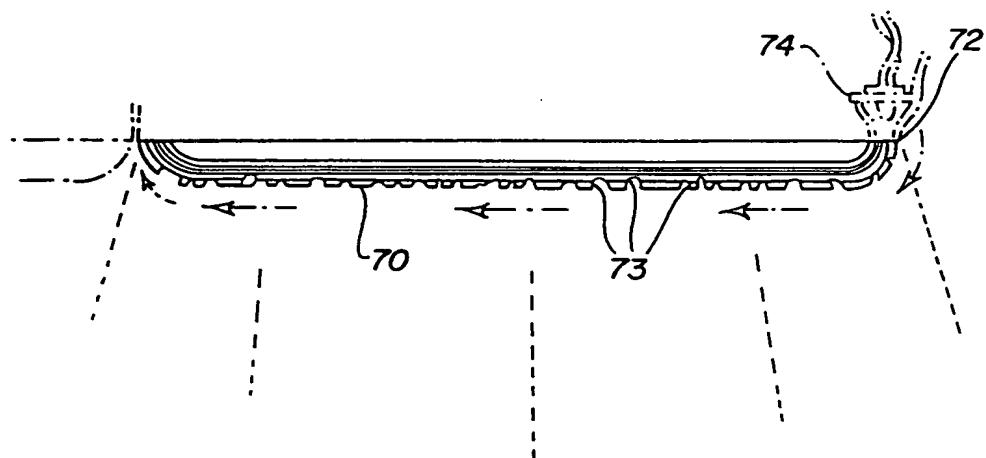


FIG-14

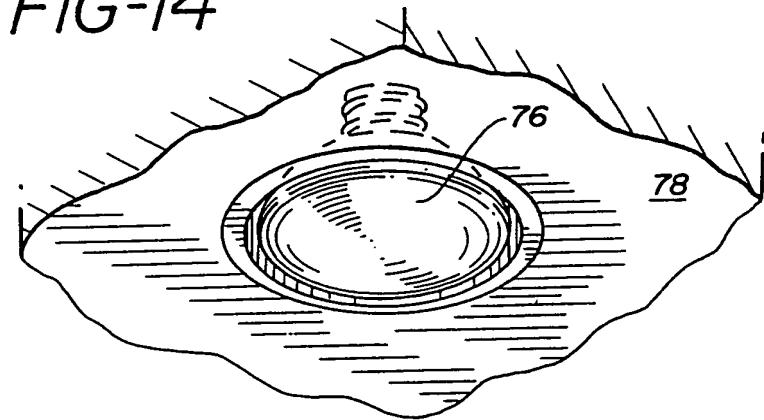


FIG-15

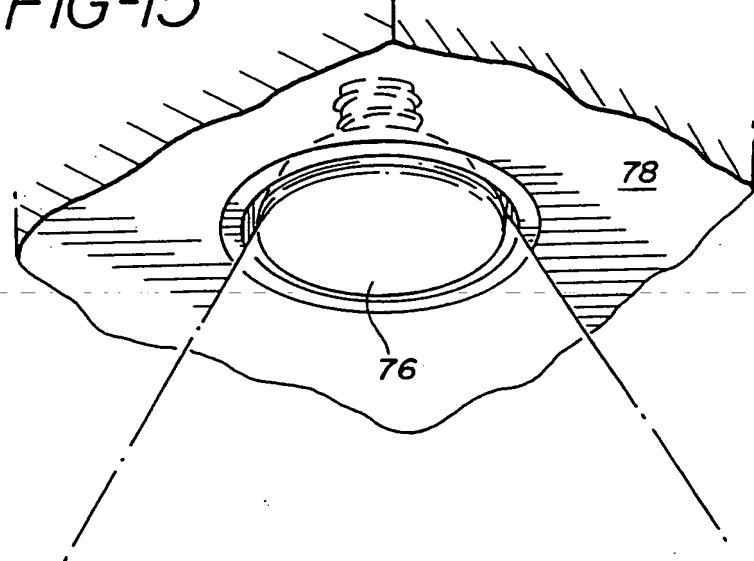


FIG-16

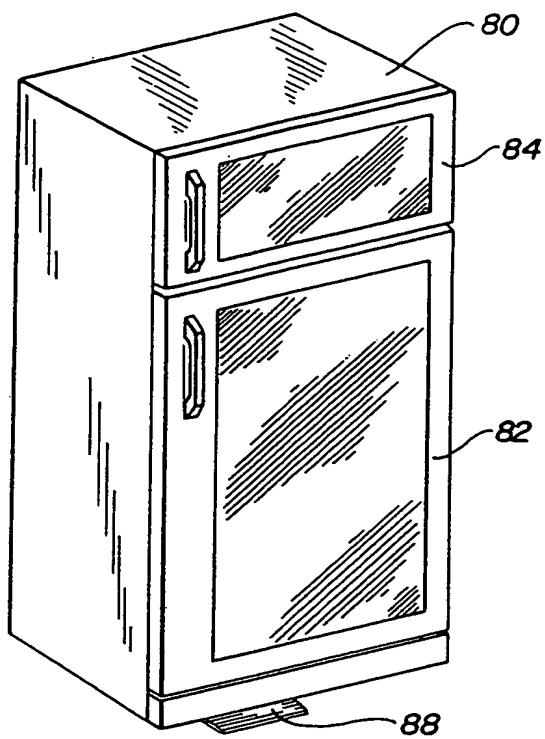
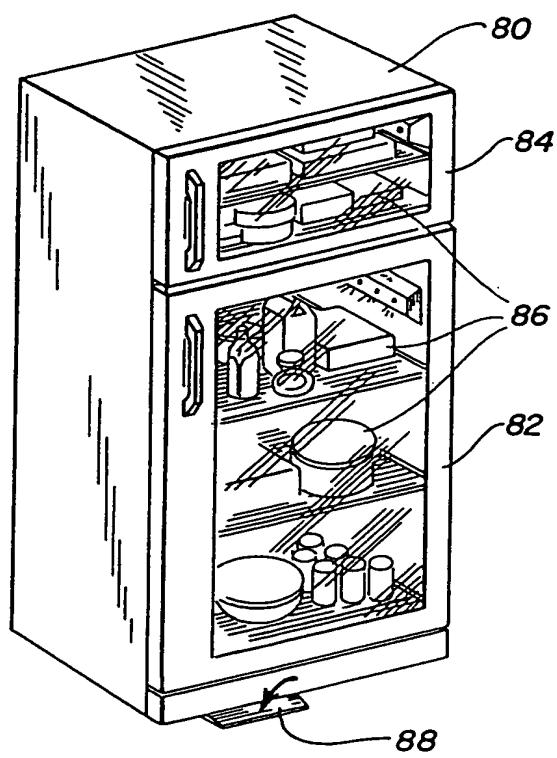


FIG-17



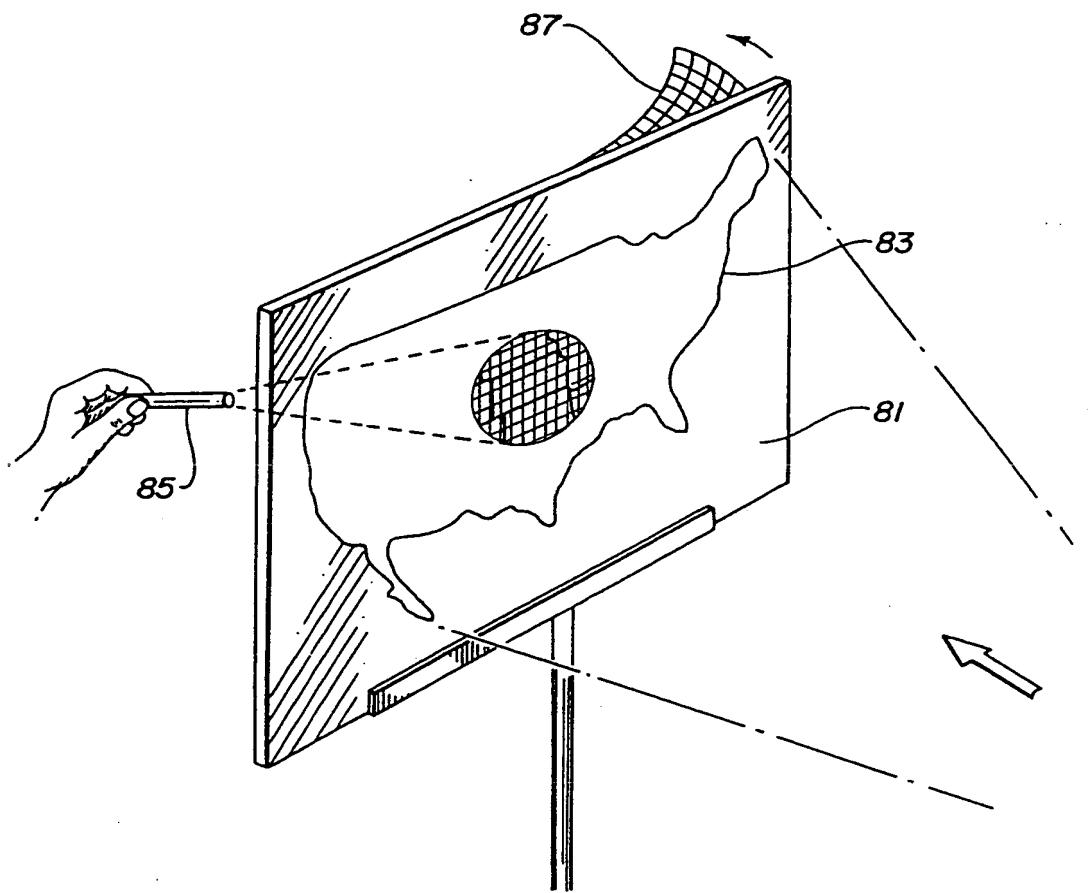
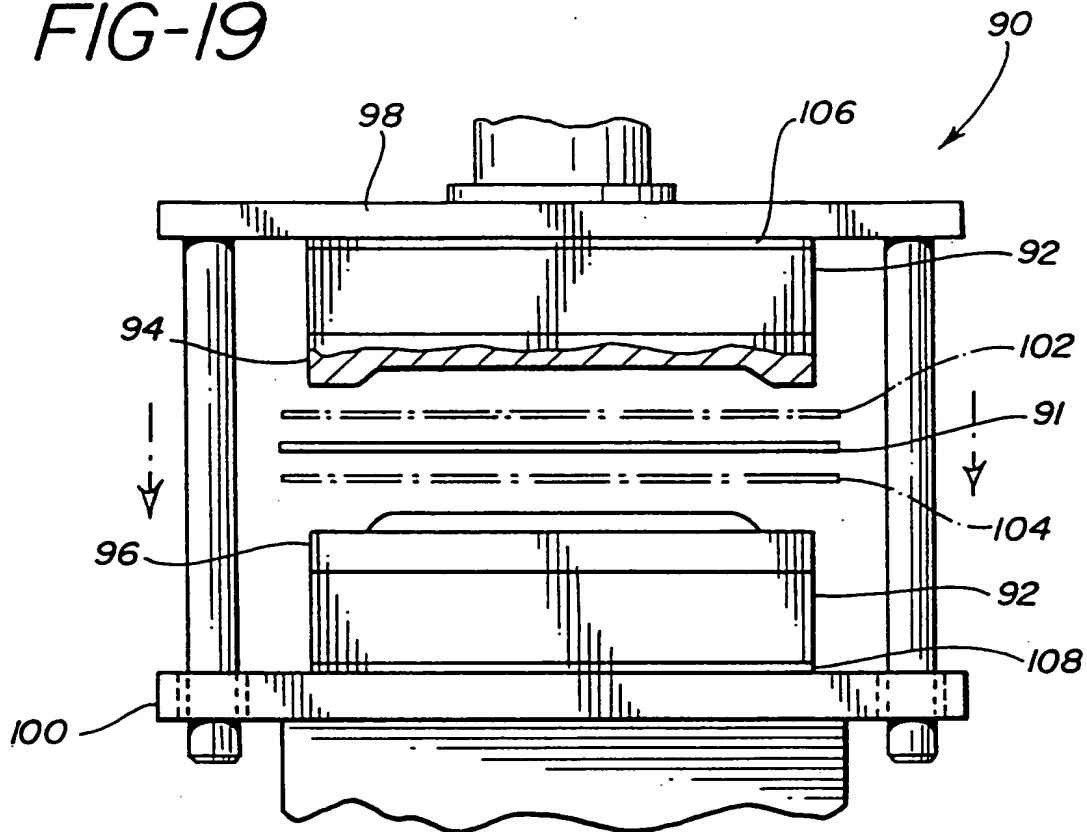
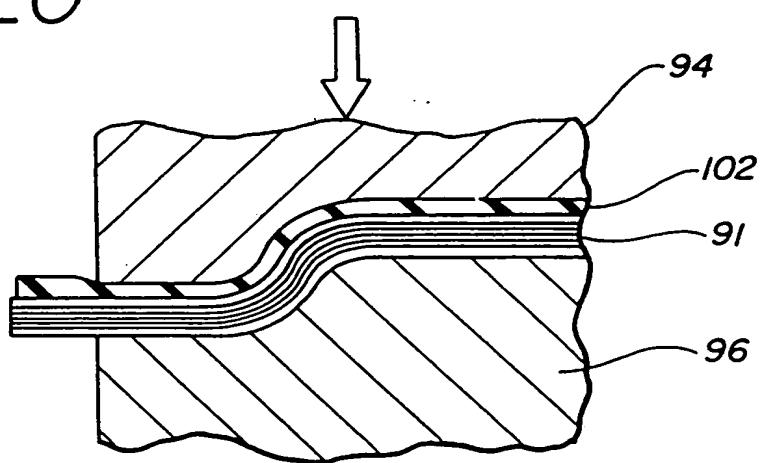


FIG-18

*FIG-19*



*FIG-20*



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